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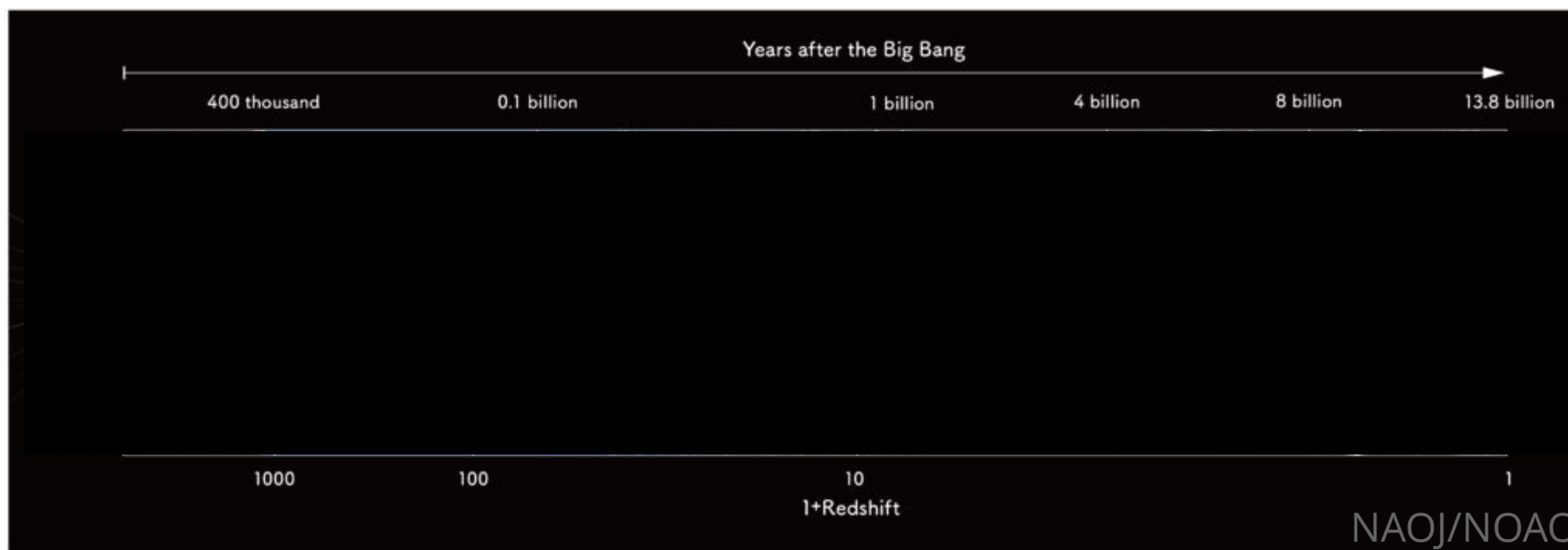
EXTENDING the EFFECTIVE FIELD THEORY of 21CM RADIATION

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*EuCAPT SYMPOSIUM
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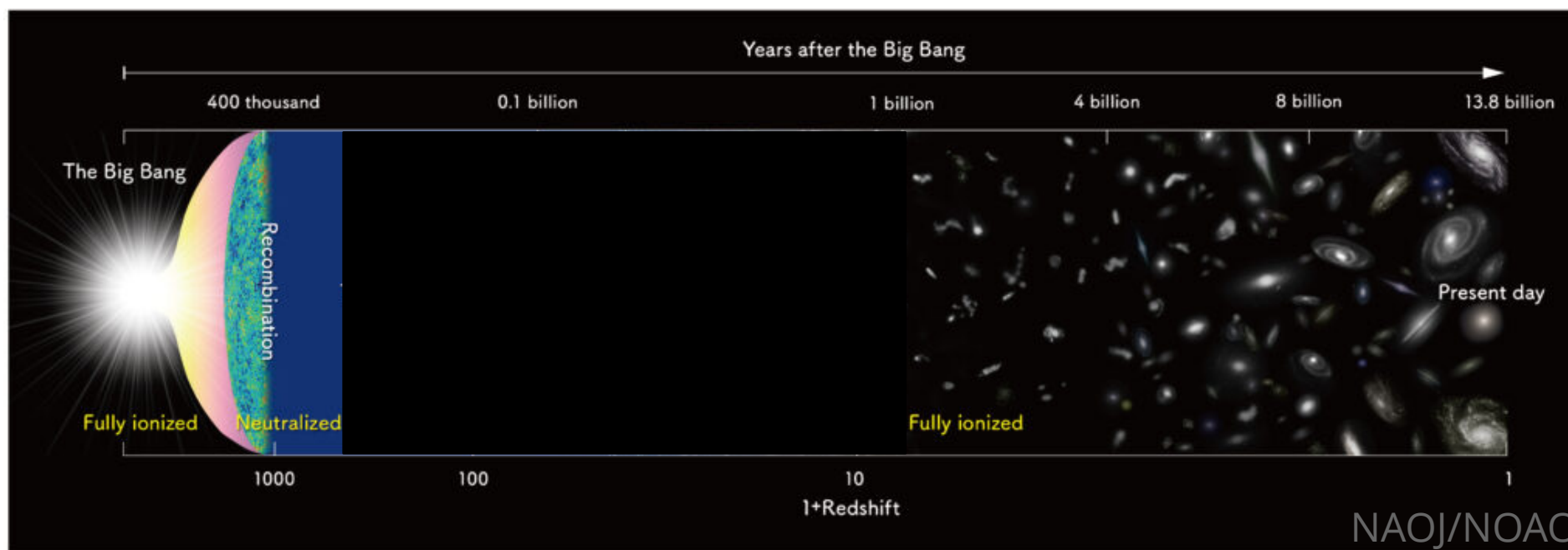
WHAT IS 21CM COSMOLOGY?

- What redshifts have we directly measured?
 - $z \sim \text{few}$: e.g. galaxy surveys
 - $z = 1100$: cosmic microwave background



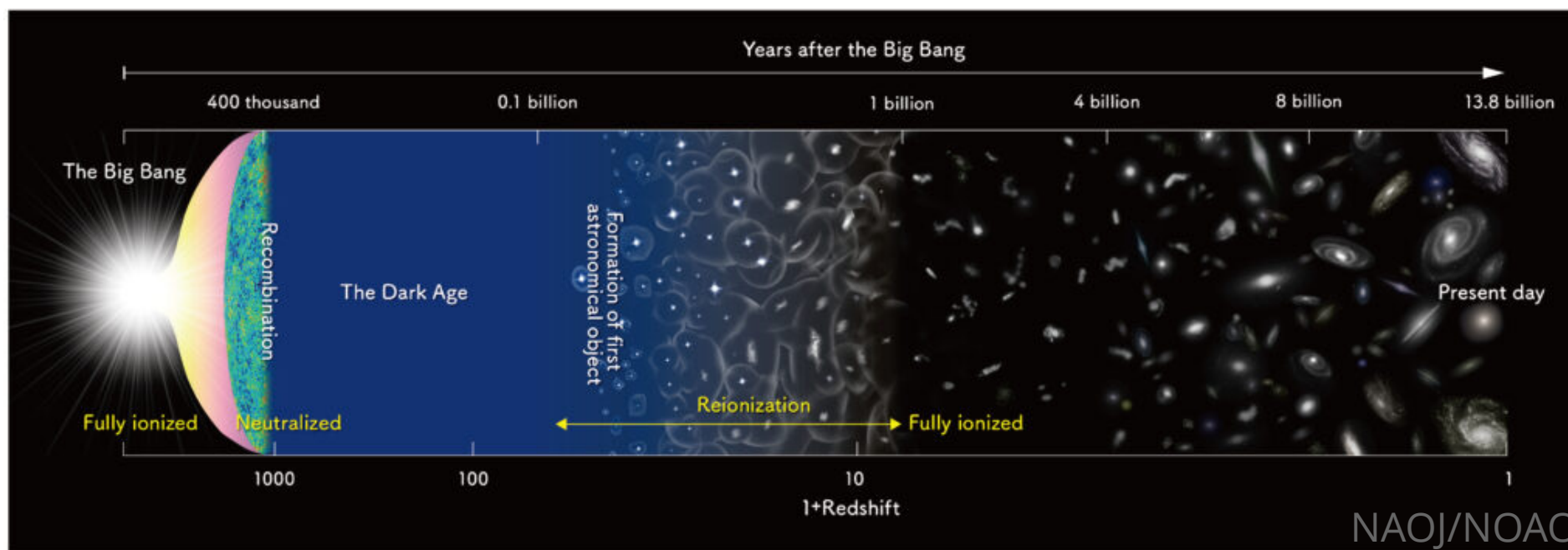
WHAT IS 21CM COSMOLOGY?

- In between, there are few stars/galaxies, only diffuse hydrogen
 - Search for the hyperfine transition of neutral hydrogen → 21cm



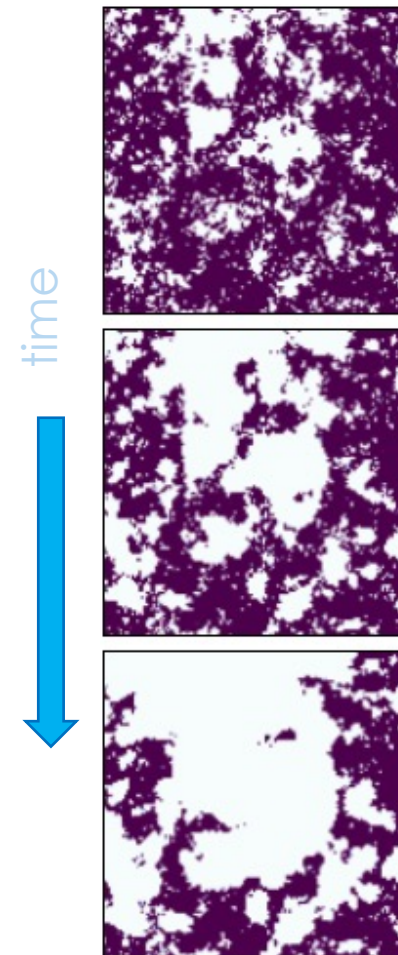
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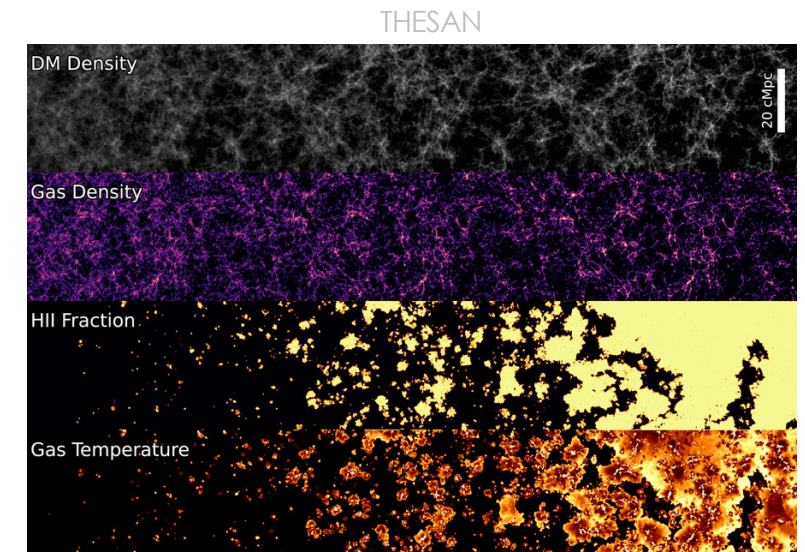
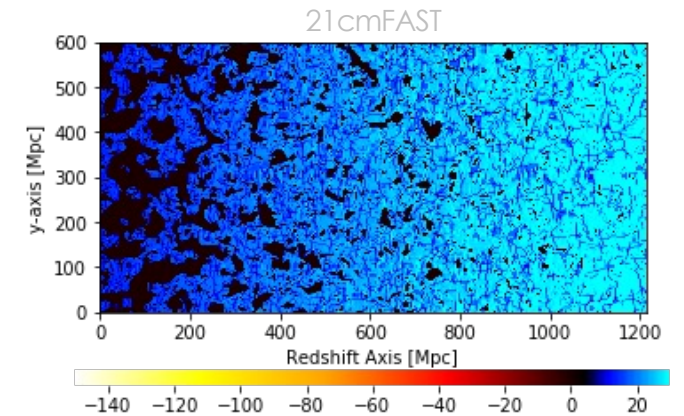


WHAT'S THE CATCH?

- Experimentally: huge foregrounds, e.g. synchrotron radiation
- Theoretically: Prevailing view has been that analytic/perturbative methods are too difficult
 - Reionization is very patchy/nonlinear
 - Instead rely on computationally expensive simulations/semi-numerics



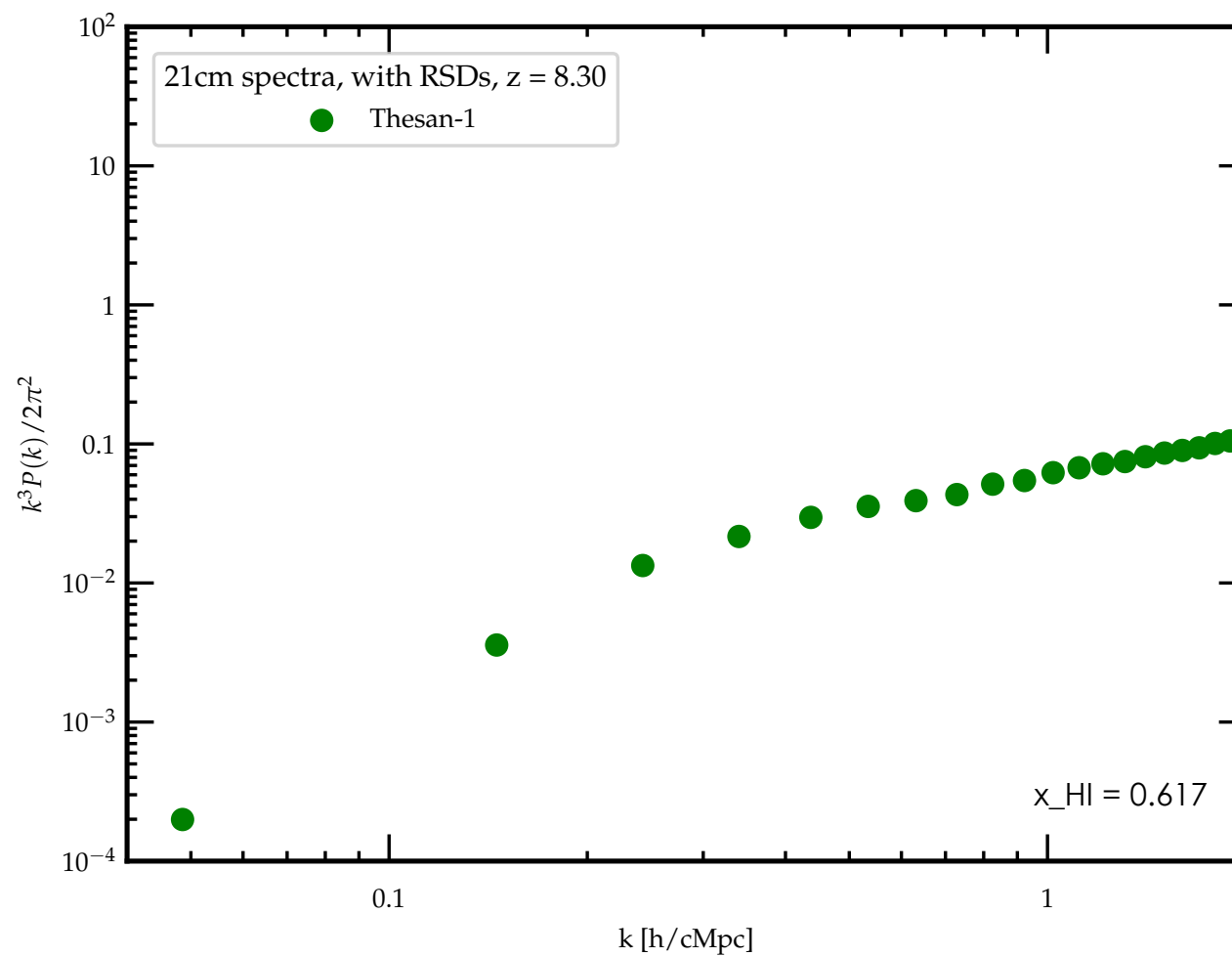
McQuinn & D'Aloisio, 2018.



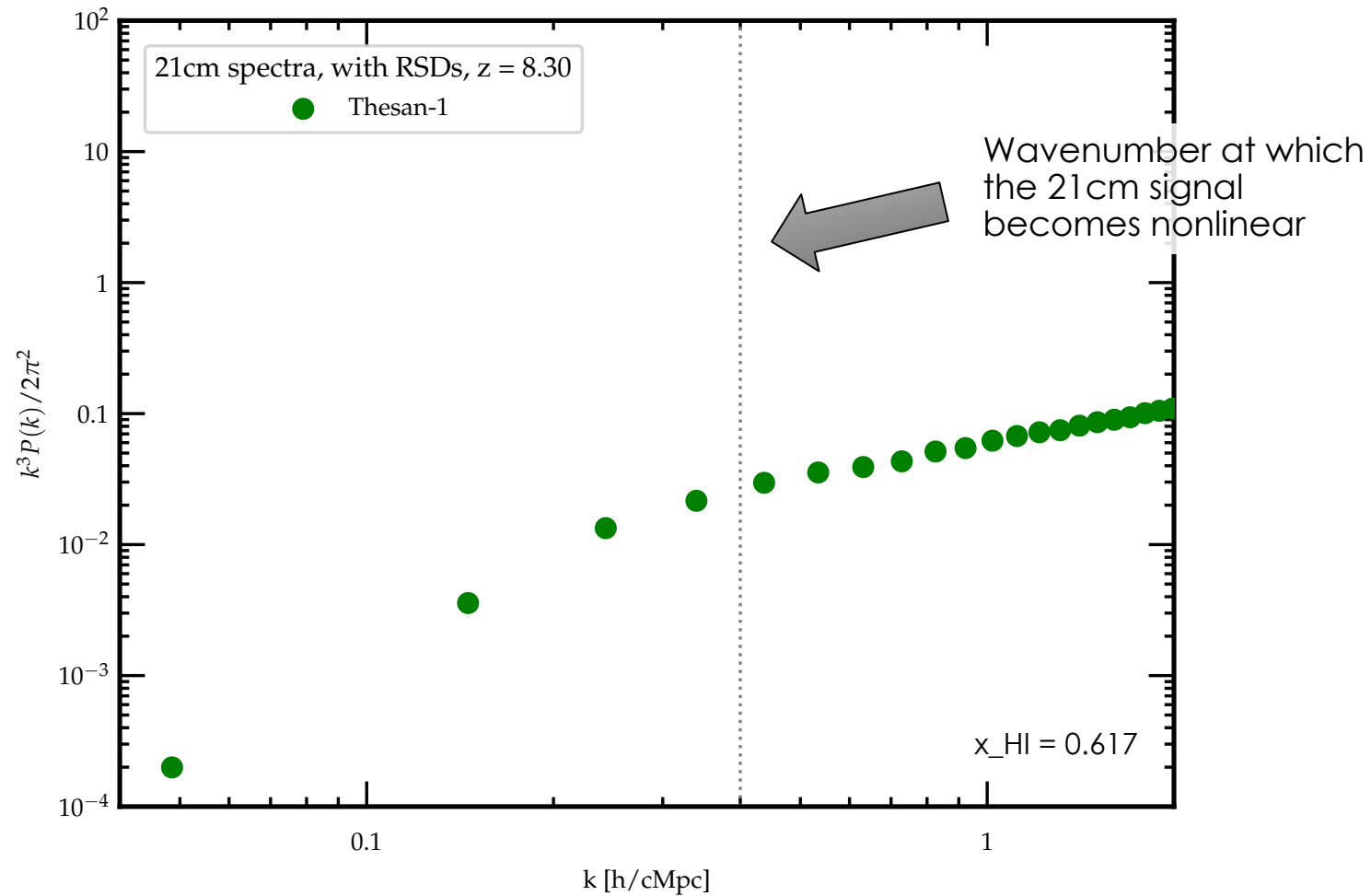
21 CM SIGNAL IS PERTURBATIVE

- Effective field theory can describe the signal on observable scales
- What does our effective field theory for 21 cm radiation include?
 - Bias expansion, since 21 cm signal traces matter density
 - Redshift space distortions, since sources have peculiar velocities
 - Renormalized bias, to deal with small scale nonlinearities

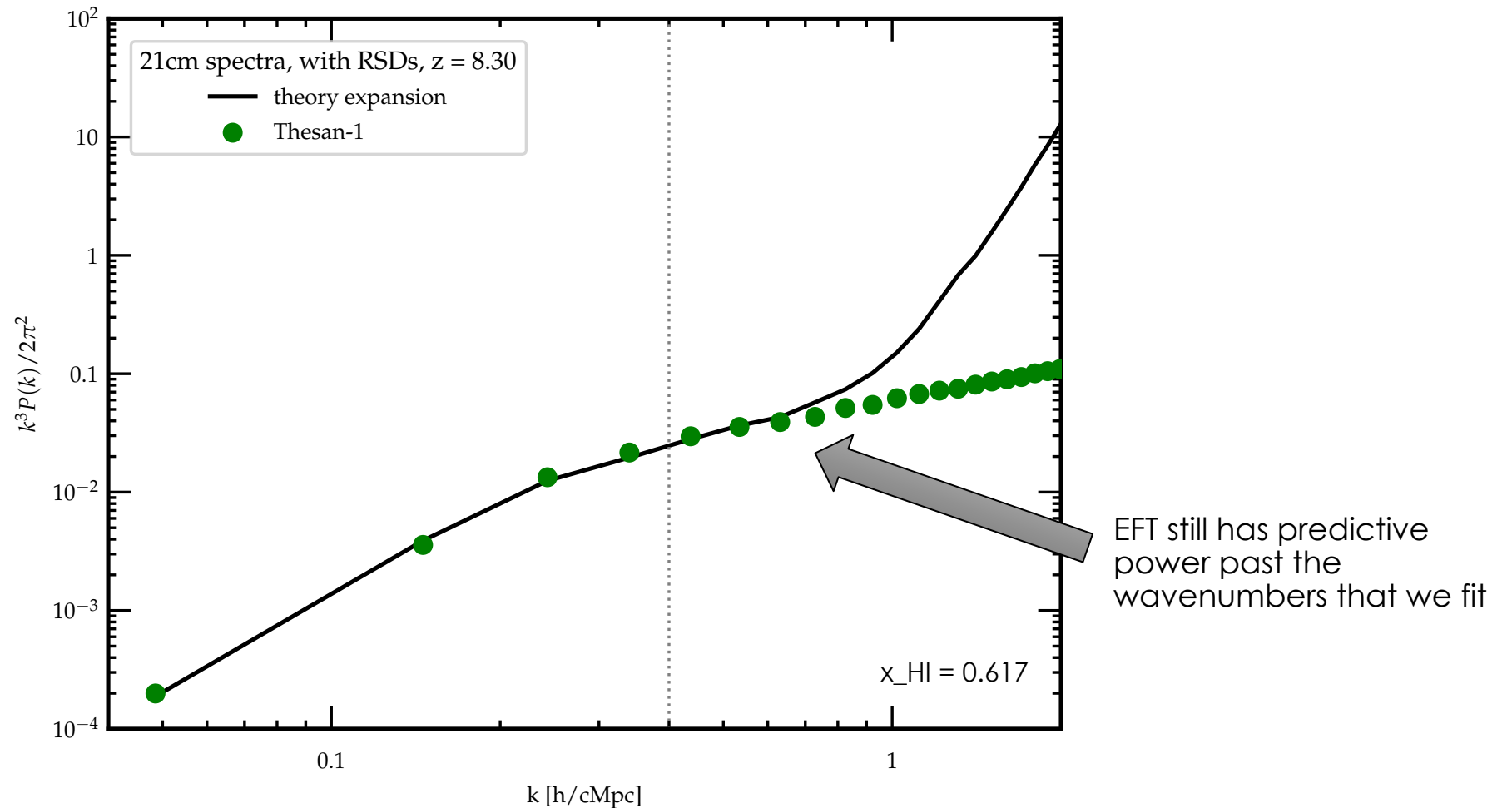
COMPARISON TO SIMULATION



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SUMMARY

- On observable scales, can use perturbative methods for 21 cm brightness temperature
- We've extended these EFT methods, e.g. including RSDs
- Theory expansion is a good fit to simulations, at early enough redshifts and large length scales
- Evolution of coefficients reflects different physics between simulations

- Future steps:
 - Spin temperature fluctuations?
 - Orthogonalize terms in the expansion